Tectonic and Eustatic Controls on Internal Architecture and Stacking Patterns of Pleistocene Shallow-Marine and Fluvial Depositional Sequences*

Claudio Di Celma¹, Gino Cantalamessa¹, Luca Ragains², and Walter Landini²

Search and Discovery Article #50621 (2012)**
Posted June 25, 2012

*Adapted from poster presentation at AAPG Annual Convention and Exhibition, Long Beach, California, April 22-25, 2012
**AAPG©2012 Serial rights given by author. For all other rights contact author directly.

¹School of Science and Technology, University of Camerino, Camerino, Italy (Claudio.dicelma@unicam.it)
²Department of Earth Sciences, University of Pisa, Pisa, Italy

Abstract

The complex interaction of regional uplift, glacio-eustasy, local tectonics, and sediment supply has a significant impact on the internal architecture and vertical arrangement of shallow-marine and fluvial depositional sequences and can be documented in well-exposed successions of Pleistocene strata cropping out along the uplifted margins of Ecuador, northern Chile, and eastern central Italy.

The results stemming from these sediments have important implications for sequence stratigraphic models in tectonically active areas and lead to the following general conclusions: (i) given that rates of syndepositional regional tectonic uplift were substantially less than rates of contemporaneous eustatic changes in sea level in all of the study areas, glacio-eustasy appears to have played the main control on development of high-frequency sequences; (ii) stratal geometries, sedimentary facies, and genetic complexity of sequence bounding unconformities of these cyclic successions indicate that the internal organization of individual depositional sequences is directly controlled by the rates of sediment supply and by the occurrence of intrabasinal, short-term normal faults striking obliquely with respect to paleo-shoreline trends; (iii) the effects of the regional tectonic uplift on these eustatic sequences is on longer term, at sequence set scale, and is responsible for their distinctive stacking pattern; owing to the progressive, tectonically driven reduction of accommodation space, high-frequency sequences are nested within a forced regressive sequence set, where each successively younger sequence is displaced basinward and downward respect to the last.
Control of coastline physiography on sequence architecture

Ecuador: Canoa and Tablazo Formations

Sheltered sequences

Exposed sequences

Ecuador: Jarma Formation

Composite stratigraphic section for the Lower Platanos synthetic accretionary wedge between Puntal Cell and Punta Kachirao (Jarma Formation). The section was deposited in shallow water, tide-dominated settings, and local environments, each with its own unique characteristics.

Di Celma, C., Cantalamessa, G., Ragagni, L., Landini, W.
University of Camerino, University of Pisa (Italy)
www.researchcom.com
The youngest part of the Pan-African block, central eastern China, is subdivided into three tectonically distinct blocks recording a complex deformational evolution since early Proterozoic time. Significant crustal thickening is recorded by high-grade metamorphic rocks in the northern part of the block, whereas the southern and eastern parts are characterized by low-grade metamorphic rocks and interleaved sedimentary sequences. The three blocks are separated by major structural discontinuities that may have acted as tectonic windows for lateral transport of material from one block to another. This study presents new geochronological data from the southern and eastern parts of the block to constrain the tectonic evolution and the timing of major tectonic events. The zircon U-Pb data (and Sm-Nd data for one sample) from the southern and eastern parts of the block indicate that the last tectonic event in the southern part of the block was ca. 1.2 Ga, whereas the eastern part is characterized by a distinct tectonic event at ca. 1.0 Ga. The results suggest that the southern and eastern parts of the block were not significantly affected by the Pan-African orogeny, whereas the northern part of the block was affected by both the Pan-African and the Phanerozoic orogeny. The study also highlights the importance of understanding the tectonic evolution of these tectonically complex regions for understanding the evolution of the Chinese craton and its interaction with the surrounding tectonic belts.

**Qc Unit**

The Qc Unit consists of two lithofacies: intertidal meandering depositional sequences (Qc1 and Qc2), ranging from 10 to 30 m in thickness, and is characterized by four depositional sequences throughout its depositional history. However, due to changes in base-level and sea-level fluctuations, the depositional history of the Qc Unit is characterized by a complex interplay of processes that have shaped the depositional environments. The depositional history of the Qc Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qc Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qc Unit is characterized by the interplay of processes that have shaped the depositional environments.

**Qm2 Unit**

The Qm2 Unit is characterized by two depositional sequences: the Qm2a and Qm2b. The Qm2a sequence is characterized by intertidal meandering depositional sequences, ranging from 10 to 30 m in thickness, and is characterized by four depositional sequences throughout its depositional history. However, due to changes in base-level and sea-level fluctuations, the depositional history of the Qm2 Unit is characterized by a complex interplay of processes that have shaped the depositional environments. The depositional history of the Qm2 Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qm2 Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qm2 Unit is characterized by the interplay of processes that have shaped the depositional environments.

**Figure 1:** Stratigraphic sections of the Qc and Qm2 Units. The Qc Unit consists of two lithofacies: intertidal meandering depositional sequences (Qc1 and Qc2), ranging from 10 to 30 m in thickness, and is characterized by four depositional sequences throughout its depositional history. However, due to changes in base-level and sea-level fluctuations, the depositional history of the Qc Unit is characterized by a complex interplay of processes that have shaped the depositional environments. The depositional history of the Qc Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qc Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qc Unit is characterized by the interplay of processes that have shaped the depositional environments.

**Figure 2:** Pedal loops within the Qc Unit are generally separated into two main facies, associations depending on whether they accumulated within the shoal-belt (CB) or on the fanplain (FP). Most conglomerate in the shoal-belt facies is of nearshore origin, whereas sand and mud in the fanplain facies are of nearshore origin.

**Figure 3:** The three subunits (A, B, and C) show a transition from subunit A to subunit C. The Qc Unit is separated into two depositional sequences: the Qc1 and Qc2. The Qc1 sequence is characterized by intertidal meandering depositional sequences, ranging from 10 to 30 m in thickness, and is characterized by four depositional sequences throughout its depositional history. However, due to changes in base-level and sea-level fluctuations, the depositional history of the Qc1 Unit is characterized by a complex interplay of processes that have shaped the depositional environments. The depositional history of the Qc1 Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qc1 Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qc1 Unit is characterized by the interplay of processes that have shaped the depositional environments.

**Figure 4:** Depositional environments of the Qm2 Unit are influenced by the color of the depositional environments. The Qm2 Unit is characterized by two depositional sequences: the Qm2a and Qm2b. The Qm2a sequence is characterized by intertidal meandering depositional sequences, ranging from 10 to 30 m in thickness, and is characterized by four depositional sequences throughout its depositional history. However, due to changes in base-level and sea-level fluctuations, the depositional history of the Qm2a Unit is characterized by a complex interplay of processes that have shaped the depositional environments. The depositional history of the Qm2a Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qm2a Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qm2a Unit is characterized by the interplay of processes that have shaped the depositional environments.

**Figure 5:** A large-scale drift motion is controlled by glacioeustatic changes. The geomorphology of the long-term drift motion is characterized by the color of the depositional environments. The Qm2 Unit is characterized by two depositional sequences: the Qm2a and Qm2b. The Qm2a sequence is characterized by intertidal meandering depositional sequences, ranging from 10 to 30 m in thickness, and is characterized by four depositional sequences throughout its depositional history. However, due to changes in base-level and sea-level fluctuations, the depositional history of the Qm2a Unit is characterized by a complex interplay of processes that have shaped the depositional environments. The depositional history of the Qm2a Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qm2a Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qm2a Unit is characterized by the interplay of processes that have shaped the depositional environments.

**Color photograph of different expression of the Qm2 Unit:** The Qm2 Unit is characterized by two depositional sequences: the Qm2a and Qm2b. The Qm2a sequence is characterized by intertidal meandering depositional sequences, ranging from 10 to 30 m in thickness, and is characterized by four depositional sequences throughout its depositional history. However, due to changes in base-level and sea-level fluctuations, the depositional history of the Qm2a Unit is characterized by a complex interplay of processes that have shaped the depositional environments. The depositional history of the Qm2a Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qm2a Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qm2a Unit is characterized by the interplay of processes that have shaped the depositional environments.

**Figure 6:** Sketch illustrating the composite nature of the Qm2 Unit. The Qm2 Unit is characterized by two depositional sequences: the Qm2a and Qm2b. The Qm2a sequence is characterized by intertidal meandering depositional sequences, ranging from 10 to 30 m in thickness, and is characterized by four depositional sequences throughout its depositional history. However, due to changes in base-level and sea-level fluctuations, the depositional history of the Qm2a Unit is characterized by a complex interplay of processes that have shaped the depositional environments. The depositional history of the Qm2a Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qm2a Unit is characterized by the interplay of processes that have shaped the depositional environments. The depositional history of the Qm2a Unit is characterized by the interplay of processes that have shaped the depositional environments.
Short- and long-term tectonic control on internal architecture and stacking pattern of Pleistocene depositional sequences (Mejillones Formation, northern Chile)

Figure 4. Schematic model that helps to explain variations in sequence architecture across normal faults in response to locally varying accommodation. Above T1, during a rapid sea-level rise and landward migration of coastal wetlands, the subaerial surface of exposure (SS) was eroded and replaced by a Glossifungites-dominated RS (coarse SB/RM). At T2, an accommodation increase, a new accommodation was created, more sediment was added to the block, and as a result, the first TST was deposited. At such time, incremental fault movement resulted in uplift of coastal bluffs and subaeration of hanging-wall blocks. During a succeeding, longer-lasting phase of rapid sea-level fall, accommodation was progressively deposited in response to a steady lowering. Waves scoured front of the highstand shoreline and continued the incision that built the TST-SS. The entire TST was then exhumed and incised by coastal erosion, forming an easterly-oriented regressive to transgressive sequence. Consequently, the entire TST and part of the underlying SB/RM sequence were eroded from the coastal front, forming an easterly-oriented, regressive to transgressive sequence.

Long-term tectonic control on sequence stacking pattern

Figure 5. Generalized depositional (top-coded) sketch (no scale implied). Illustrating a conceptual model for the development of systems tracts and bounding surfaces down the axis of the gulf. The northerm propagation of the Pampa de Los Alamos highstand was terminated through frontal regression and planar landward shift of littoral control by glacio-eustatic, eustatic-regime, and high-frequency sea-level fluctuations superimposed on a tectonically-driven long-term sea-level fall. Systems, which may have been partially destroyed by subaerial processes during the emergence stage and erosional incision during the next transgression, are stacked in an overlapping configuration and, as a whole, represent a terminally-enhanced, falling-stage sequence set. Boundaries of other sequences, that formed during sea-level fall, subaerial exposure of the shelf and subsequent sea-level rise and erosional overstepping, are transgressive conformity by the successive eustatic surface. Consequently, the falling-stage sequence set is bounded by a complex surface that develops discontinuously from the downlaps to merging of erosional composite sequence boundaries.